DEPARTMENT OF THE INTERIOR, CANADA

HON. THOMAS G. MURPHY, Minister R. A. GIBSON, Assistant Deputy Minister

GEODETIC SURVEY OF CANADA

NOEL J. OGILVIE, Director

ANNUAL REPORT

OF THE DIRECTOR

OF THE

GEODETIC SURVEY OF CANADA

FOR THE

FISCAL YEAR ENDING MARCH 31, 1935

OTTAWA
J. O. PATENAUDE, I.S.O.
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
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OPERATIONS OF THE GEODETIC SURVEY OF CANADA

Top—Geodetic Survey Building at Ottawa.
Second row, left to right—
  North end of Standard building, showing five-metre apparatus.
  Office of Precise Level Adjusting Division.
  Fiducial point at south end of 50-metre comparator, in Standard building.

Third row, left to right—
  Precise Level, U.S.C. & G.S. Pattern.
  Latest Model Primary Triangulation Model theodolite.
  Latest Model Astronomical Transit.
  Electric Signal Lamp for Primary Triangulation.
  Precise Level, Zeiss Model.

Bottom row, left to right—
  Observing on Secondary Triagulation.
  Photographic and Transport Hydroplane, Canadian model.
  Sending instructions to light keepers by heliograph.
  Setting rear end of tape in Base-line measurement.
  Observing Precise Levels in the Yukon Territory.
  A Transport Hydroplane at rest.
  Observing Primary Triangulation.

On flanks—
  Triangulation Tower near Chatham, Ont., with Lamp-stand extended 37 feet. Height of Lamp-stand: 147 feet.

THE GEODETIC SURVEY OF CANADA

ANNUAL REPORT OF THE DIRECTOR, NOEL J. OGILVIE

INTRODUCTION

The Geodetic Survey of Canada, Department of the Interior, is in charge of operations comprising triangulation reconnaissance, primary triangulation, precise levelling, geodetic astronomy, triangulation base-line measurement, isostasy, geodetic research, triangulation adjustment, precise levelling adjustment, and the publication of geodetic survey data.

Field operations were carried on by Geodetic Survey parties in the provinces of New Brunswick, Nova Scotia, Quebec, Ontario, Saskatchewan, Alberta, and British Columbia.

An Order in Council was passed ordering mean sea-level as determined by the level system of the Geodetic Survey of Canada to be the official datum for all Government surveying and engineering operations and to be known as the Canadian Geodetic Datum.

The issuing of a series of publications entitled "Altitudes in Canada" was continued. Two publications of this series covering the province of Quebec were printed and are being distributed by means of special mailing lists. Numerous requests for these and former publications of this series were received.

An important link in the chain of triangulation nets in the Georgian Bay area was completed and the final adjustment for publication of results in this area is now in hand.

An aerial reconnaissance for the selection of triangulation stations in the district westward from lake Nipigon was made.

The elevations of a number of points on Turtle mountain, near Frank, Alberta, were established in connection with a scientific investigation as to its stability.

Recent adjustments of the precise level net of Canada were checked in an extensive study, which included a comparison of sea-level on the Atlantic and Pacific oceans and the manner in which the level nets of Canada and the United States are affected.

The longitude and latitude of seven triangulation stations were determined by star observations. The lengths of four invar wires were determined for the International Bureau of Standards.

The problem of the direct and inverse solutions of long geodetic lines has received further attention and a manuscript dealing with this was printed.

Requests for geodetic control data were received in increased numbers from Dominion and provincial Government departments, municipal corporations, and the engineering and surveying public, and the most recently determined data were supplied.

Five publications of the Geodetic Survey of Canada were printed. The preparation of manuscripts has been carried on. Special mailing lists, after

revision by means of notification and acknowledgment cards, were used in the distribution of publications.

CANADIAN GEODETIC DATUM FOR ELEVATIONS

Every material undertaking by man for human advancement involves levels in some form or other. This is true regardless of the fact that it may be a homesteader attempting to drain his land or an engineer designing the building of a transcontinental railway. As soon as level records begin to accumulate, it becomes necessary to refer them to one common point or surface, in order that the difference in height between two points may be known. Generally the lowest point in any system of levels is selected as the starting point and assigned an elevation which may be 0 or 100 or 1,000 feet as is arbitrarily selected. Such a system, although based on an assumed elevation, is for all practical purposes satisfactory as long as it remains self-contained. The difference in the elevations of two points each based on the assumed elevation of the starting point or datum surface gives correctly the difference in height between the two points and as long as all elevations concerned are based on this arbitrary datum, no confusion will arise. However, the instant another system of levels based on another datum is encountered, no longer does the difference in the recorded elevations of two points necessarily give the correct difference of their heights. It is the clashing of level systems based on different datums that causes confusion. Obviously if all level systems were based on one common datum, this confusion would disappear.

If before any development took place in a country there were laid down an adequate level system then it would be quite possible to base all surveying and engineering operations on a common datum. Unfortunately such an ideal arrangement although economically sound in principle has never been carried out in practice. The history of any country reveals that as each new development requiring levels takes place, the best available datum is adopted, or by reason of the non-existence of any datum, an arbitrary datum is created.

When the question of a common datum is being considered, many factors have a bearing on this problem. For instance, it is evident when a city is adopting an official datum for its street grading, its water and sewer systems, that all computations would be simplified and the probability of confusion lessened if the datum used by the railways, provincial engineering departments and other engineering organizations could be adopted. Also when a province considers this problem, its decision should be influenced by the datums in use in adjoining provinces. Finally, when a country like the Dominion of Canada, with its wide domain, is confronted with this question of what datum to adopt, it is clear with even slight consideration that an ideal datum is one which may be established independently at different places. There is only one reference surface that fulfils this requirement, and this is mean sea-level. This is the reason why mean sea-level has been universally adopted by every country as the datum surface for elevations. It may be defined as the surface which the water of the ocean would assume were it not acted upon by the attraction of the sun and the moon or disturbed by the wind. Not only is it an ideal datum surface because it may be obtained at any point on our coastlines, but in addition it is invariable inasmuch as it is independent of land movement such as a subsidence of land in any section. Such a movement might be most difficult to detect from bench marks themselves as all would be subject to the same general change, but a re-determination of mean sea-level in the vicinity would definitely reveal the magnitude of any such movement. A fair determination of mean sea-level, within a small fraction of a foot, may be obtained from continuous tidal observations covering a period of one year. But for the requirements of a national level system, it is considered necessary to extend the period to seven years in order to obtain a precise value of mean sea-level at a principal tidal station.

The first precise levels in this country were run by the Department of Public Works in 1883. They were started from a United States Coast and Geodetic Survey bench mark at Rouses Point, New York, and were carried along the Richelieu river to Sorel on the St. Lawrence river. The purpose for which this precise levelling was carried on was to establish accurate vertical control for harbour and river improvements. All the levels run by the Department of Public Works were adjacent to waterways and were mainly restricted to Eastern Canada along the St. Lawrence river and the Great Lakes. That department continued to run precise levels until 1931, at which time its system comprised some 5,600 miles of precise levels with some 3,800 bench marks.

At the inception of precise levelling operations by the Geodetic Service, it was obviously impossible to give out adjusted values for elevations of bench marks by reason of the fact that adjusted values could not be ascertained until the national system of levels had been developed. On this account it was the policy of this Service after the field operations of each season had been completed, to release instrumental values of elevations for bench marks. Such values were clearly stated to be preliminary but would be held without change until adjusted values could be released. It was not until 1928 that the national system of levels had reached that stage when values resulting from its adjustment could be held indefinitely without further change. Subsequently these adjusted values were issued in a series of ten precise levelling publications covering the Dominion from east to west.

In 1931 the Department of Public Works transferred to the Geodetic Survey all original field books and records resulting from the precise level operations carried on by that department since 1883. When in 1934 the amalgamation and co-ordination of these levels with the Geodetic Survey system was completed, all precise levelling in this country had been brought together under one organization and had been consolidated into one national system.

The official status and significance of the Canadian Geodetic Datum is set forth in the Order in Council of March 11, 1935, establishing it, and this being concise and self-explanatory, is given hereunder. The Order in Council reads as follows:—

Whereas the Minister of the Interior reports that the Geodetic Service of the Department of the Interior has been carrying on precise levelling since 1906;

That in 1931 the Department of Public Works transferred all original field books and records, resulting from precise level operations carried on by that department since 1883, to the Geodetic Service of the Department of the Interior;

That since that time all precise levelling in Canada has been brought under one organization and has now been consolidated into one national system of levels referred to one datum plane;

That a number of different datum planes have been, and still are, in use in Canada and that this condition tends to confusion;

That mean sea-level has been generally adopted by other countries as their datum plane for elevations and is the datum plane to which the national system of precise levels of the Geodetic Service of the Department of the Interior has been referred;

Therefore His Excellency the Governor General in Council, on the recommendation of the Minister of the Interior, is pleased to order and it is hereby ordered that mean sea-level, as determined at coastal points by the Canadian Hydrographic Service and extended inland by the Canadian Geodetic Service, shall be the official datum plane for elevations in Canada and shall be known as the Canadian Geodetic Datum;

His Excellency in Council is further pleased to order that the elevations of all works or projects of the Government of the Dominion of Canada which may originate after the date hereof shall be referred to this datum, where possible.

LEVELLING ON TURTLE MOUNTAIN

The surveying and engineering organizations of Canada have, in the Levelling division of the Geodetic Survey of Canada, a service which determines the exact elevation of definite points required in connection with any important development in, or adjacent to, the settled portion of the country. Levelling operations were begun by the Geodetic Survey of Canada at the end of 1906, and

at present in 1935, the lines of levels forming control nets from the Atlantic to the Pacific total 24,725 miles, exclusive of the 5,600 miles of levelling executed by the Department of Public Works, which have recently been absorbed in the Geodetic Survey system of levelling.

Advantage was recently taken of this system of vertical control when the stability of Turtle mountain, in the province of Alberta, was undertaken as a scientific investigation.

In the year 1903, a section of Turtle mountain was carried away in a landslide which buried a number of homes in the town of Frank, Alberta, killing 88 of the hapless occupants.

For years following this disaster the land lying adjacent to the path of the slide was avoided by settlers and a number of business premises in the town of Frank were dismantled or deserted. Later, as memories of the disaster faded and another generation grew up, people began to reoccupy this area. The Dominion Government, alive to the public safety and welfare, took steps to protect citizens and give necessary warning of danger.

An eminent Canadian geologist, Dr. John A. Allan, was retained to investigate and report on the condition of Turtle mountain, with a view to finding out whether or not danger was present in the area surrounding its base.

During the summer of 1933, Dr. Allan made a study of the mountain structure and carried out a plane-table survey of the main fissures along the top of the mountain. In his report he expressed the opinion that movement was taking place in that portion known as South peak and that a real danger existed that another slide might occur.

On the recommendation of Dr. Allan the Alberta Government requested that the Geodetic Survey undertake the determination of the magnitude of the subsidence, if any, of South peak, by means of precise level bench marks established on this peak as well as on two other nearby peaks, designated as North and Third. The stability of the two latter peaks being unquestioned, any movement in South peak would be indicated by the periodic determination of the relative difference of elevation between the bench marks.

A precise level party of the Geodetic Survey of Canada was engaged on this work during the month of July, 1934. A bench mark was established at each of three locations, and as a measure of precaution against destruction by irresponsible persons, a reserve bench mark was established in a concealed position.

The bench marks on Third, North and South peaks are at altitudes of 7,238, 6,921 and 7,220 feet respectively, while that of the initial bench mark at the base is 4,207 feet. The greatest distance between the peaks is 2,150 feet. The instruments used were a No. 3 level and 12-foot invar levelling rods. The levelling, forward and backward, to the top of Third peak, through a vertical distance of 3,030 feet required six days, each way. A further three days completed the levelling between the peaks.

It is hoped that the levels to the top of the mountain may be repeated at some future date by following another slope. It would permit an excellent opportunity for investigation work in connection with the study of errors encountered in levelling in a mountainous country. The present precise levelling procedure and technique has been evolved from experience of levelling operations in a flat or rolling terrain. No doubt greater experience in levelling in mountainous country would tend to introduce certain modifications in the present procedure.

As regards the original purpose of the work, to determine the stability of South peak, definite conclusion will have to await subsequent determination which no doubt will be carried out each year. Any marked movement will become apparent on the first re-determination, but should the movement be small, it might require several years to reach definite conclusions.

THEODOLITE INVESTIGATION

In the 1934 report a short description was given of an investigation of errors of angle measurement with a light type $5\frac{1}{2}$-inch theodolite designed for triangulation of the highest order. These errors might be as large as two to four seconds, though usually under one second, and were found to be caused by slight changes in the shape and fit of the cylindrical steel alidade and telescope axes subsequent to manufacture. These misfits, although seldom noticeable by any stiffness in the action of the axes, produced strains in the metal which were carried through the standards and telescope and caused deflections in the line of collimation of the telescope. These deflections varied as the telescope was swung in azimuth and altitude and resulted in angular errors of appreciable magnitude.

The method of observation by which these errors were detected was rather complicated and cumbersome, so an effort was made to devise a means whereby the deflection at various azimuths around the circle could be directly evaluated. The method evolved was to measure a 60° angle between collimators in six series with the base of the theodolite (footscrews) moved 60° counter clockwise with reference to the collimators between each two series. The six series of angles would be affected by different strain errors, and it was found possible to determine the error of pointing at each 60° interval around the circle. By an analysis of the results it was found possible to judge whether the strain was in the alidade axis or the telescope axis or both. In addition the graduation errors at 60° intervals of the horizontal circle could be computed.

The method of test is applicable to angles which are certain even divisions of the complete circle, such as 36°, 45°, 60° and 90°. It can also be applied to the outdoor measurement of these angles.

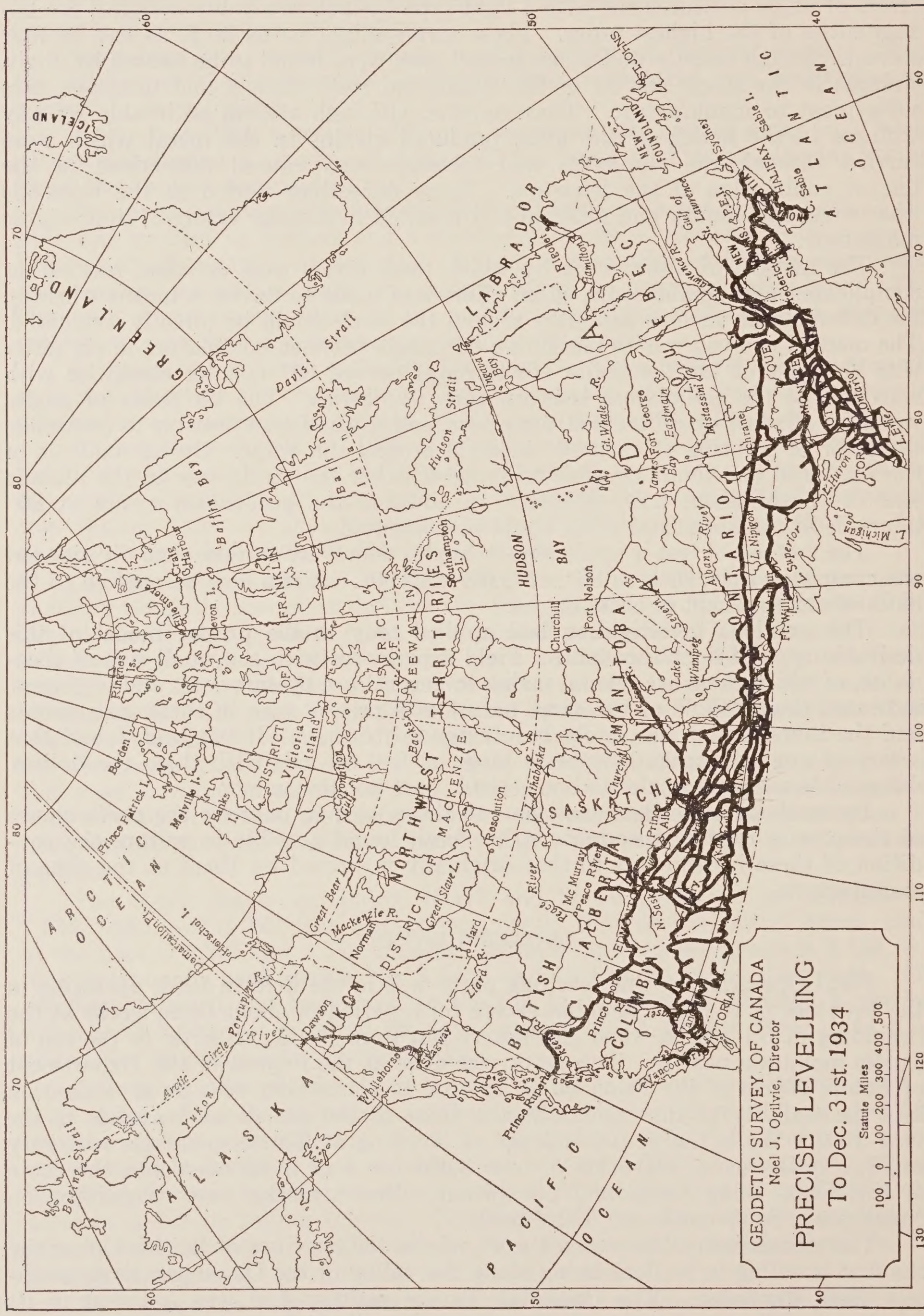
The previous investigation had applied only to the precise model of this desirable type of light theodolite. Field experiences with the small size of theodolite, of which there are several makes in general use by surveyors and engineers, indicated that trouble of the same nature was present also in these instruments and the investigation has lately been extended to them. It has been found that errors of angular measurements as large as five seconds with these theodolites, designed to measure angles to one second, were not uncommon.

By methods somewhat analogous to those used to improve the performance of the precise type of theodolite it has been found possible to restore the condition of these instruments to that originally possessed by them at the time of manufacture.

LEVELLING DIVISION

Field Operations.—One levelling party was in the field in 1934, operating in the Province of British Columbia except for a period of about three weeks at the beginning of the season when levels were run from Frank, Alberta, to the top of Turtle mountain nearby. This work was done at the request of the Department of Public Works of the Province of Alberta, in connection with an investigation into the stability of this mountain, the scene of the disastrous landslide in the year 1903. While the actual mileage of levelling at Turtle mountain was very small, a difference of elevation of over 3,000 feet had to be overcome, the route of the levels being rough and precipitous. Bench marks were established on North peak, South peak and Third peak.

The remainder of the season's work was in the province of British Columbia, the first levelling to be done being along the valley of the Okanagan river southerly from Penticton. The Canadian Pacific railway line was followed to its terminus at Oliver and thence the Penticton-Oroville highway to the international boundary; the levels were continued a short distance beyond the boundary to connect with bench marks of the United States Coast and Geodetic Survey at Oroville, Washington.


GEODETIC SURVEY OF CANADA
Noel J. Ogilvie, Director
PRECISE LEVELLING
To Dec. 31st. 1934
Statute Miles
100 0 100 200 300 400 500

Another line to the international boundary was then run, from Nelson to Nelway, following the Great Northern railway from Nelson to Salmo and thence the Nelson-Spokane highway to the boundary. At this point connections were made with bench marks of the United States Geological Survey and also with bench marks of the Geodetic Survey of Canada established in 1930 by a line of levels from Castlegar.

From Salmo the levels along the Great Northern railway were continued to Columbia Gardens, thus forming a cross connection between the two lines having their termini at Nelway. Fundamental bench marks were established at Nelson and Trail.

At the time the main line of precise levels was run through southern British Columbia several years ago, there was no railway connection along the shore of Kootenay lake between Procter and Kootenay Landing, and hence no route for the levelling between these points. A water transfer by means of staff gauges was used to bridge the gap, but this has never been considered entirely satisfactory on account of the likelihood of a water slope at the entrance to the west arm of the lake near Procter. As Procter and Kootenay Landing have now been connected by railway, it was decided to extend precise levels between these points and supersede the water transfer. This work, therefore, formed part of the British Columbia levelling party's program.

The following is a detailed statement of the mileage of levelling run in 1934-35:—

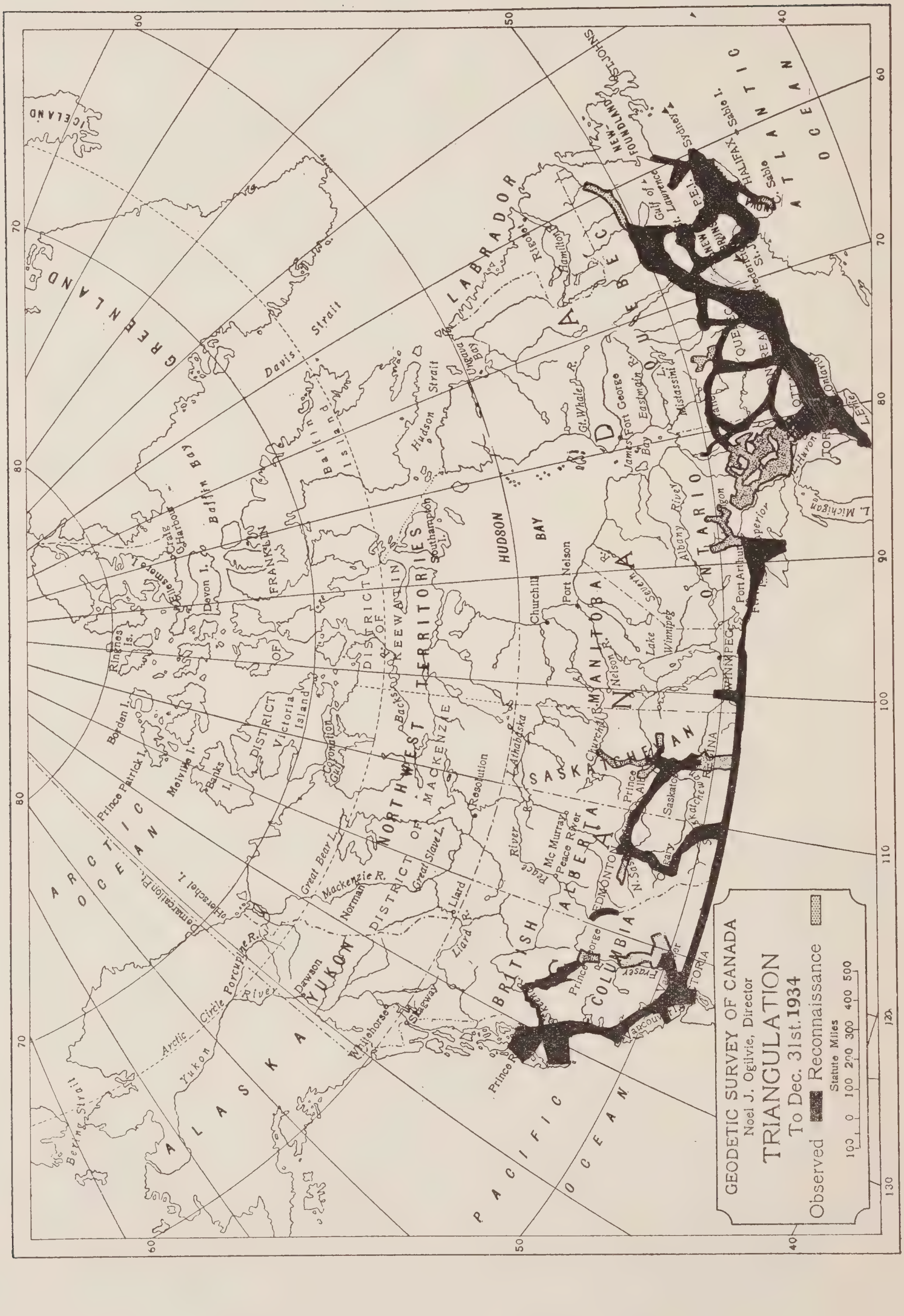
	Miles
Precise Levelling—	
Procter to Kootenay Landing	34·8
Secondary Levelling—	
Frank, Alberta, to top of Turtle mountain	4·2
Penticton. B.C., to Oroville, Washington	42.3
Nelway to Nelson, B.C.	41.8
Salmo to Columbia Gardens, B.C.	20.4
Total	108·7

Of the 144 miles levelled, 57 were on the Canadian Pacific railway, 46 on the Great Northern, and 41 along roads. Sixteen precise and 48 secondary bench marks were established.

Inspection of Bench Marks.—The work of inspecting and redescribing bench marks taken over from the levelling system of the Dominion Department of Public Works was continued during 1934. Bench marks along the railway line between Toronto and North Bay were inspected, together with branches to Collingwood, Midland, and Trenton, also from North Bay to Arnprior, including the branch from Mattawa northerly. Further inspections covered the railway lines between Montreal, P.Q., and Cornwall, Ont., and between Levis and Sorel, P.Q. In all some 480 bench marks were visited.

SUMMARY

	Miles	B.M.
Precise Levelling—		
Prior to 1934	24,690	8,670
1934	35	16
Total	24,725	8,686
Secondary Levelling—		
Prior to 1934	11,345	3,932
1934	109	48
Total	11,454	3,980


GEODETIC SURVEY OF CANADA
Noel J. Ogilvie, Director
TRIANGULATION
To Dec. 31st. 1934
Observed
Reconnaissance
Statute Miles
100 0 100 200 300 400 500

The total mileage of levelling, as divided among the different provinces at the end of the year 1934-35, was as follows:—

Province—	Precise	Secondary
Nova Scotia	729	0
New Brunswick	1,096	0
Quebec	3,418	640
Ontario	5,997	1,324
Manitoba	2,263	368
Saskatchewan	4,113	5,098
Alberta	2,866	3,799
British Columbia	3,690	225
Yukon Territory	458	0
State of Minnesota (U.S.A.)	89	0
State of Vermont (U.S.A.)	6	0
Total Mileage	24,725	11,454

TRIANGULATION DIVISION

Field Work.—During the season of 1934 one primary net 77 miles in axial length in the Georgian Bay area was added to that already completed, and an aerial reconnaissance of 380 miles of primary nets and 546 miles of secondary triangulation in northern Ontario was made. The following table shows the relevant data concerning the triangulation nets of the Geodetic Survey of Canada:—

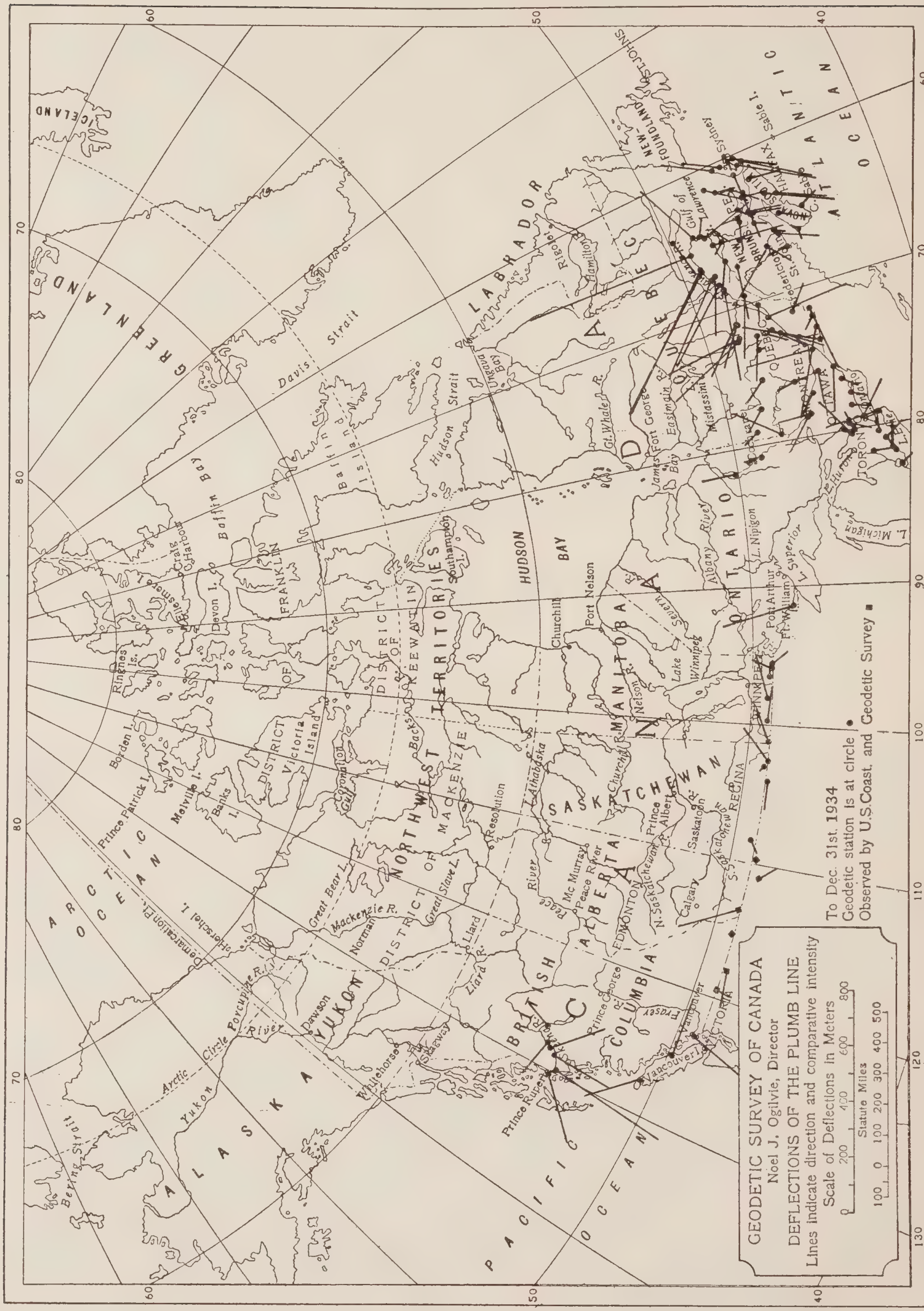
TRIANGULATION NETS OF THE GEODETIC SURVEY

Field Operations	Prior to 1934	1934	Total
	Miles	Miles	Miles
Completed primary triangulation, axial length	7,475	77	7,552
Completed secondary triangulation, axial length	1,023	28	1,051
Primary reconnaissance, observing not yet started; axial length	2,300	380	2,680
Secondary reconnaissance, observing not yet started; axial length	292	546	838
Precise traverse, length	503	-	503

Field work was completed on a net along the Bruce peninsula and to Manitoulin island connecting the previously completed nets at the south and north ends of Georgian bay, Ontario. This is the final link of a number of circuits in northern Ontario and northern Quebec and the final adjustment and preparation for publication of results of some 1,200 miles of triangulation in these areas is now in hand.

In 1933 work was started on a net having the same purpose and was partially completed. This scheme involved the observation of a number of lines across Georgian bay, and owing to the lack of height of the terminal stations abnormal refraction was necessary to make the stations intervisible. As these abnormal conditions did not occur with sufficient frequency to permit all of the observations to be made, an alternative net was laid out along the Bruce peninsula in the fall of 1933. It was this alternative net which was observed in 1934. The original primary stations along the east, or Parry Sound, shore of Georgian bay are now considered as secondary stations. Ten primary stations and four secondary stations were observed in 1934.

In January and February, 1935, an aerial reconnaissance was made for the selection of triangulation stations on 380 miles of primary nets and 546 miles of secondary nets in the area west of lake Nipigon in northwestern Ontario. Roughly all of the district of Thunder bay west of lake Nipigon and south of the northernmost transcontinental railway was covered by primary or secondary reconnais-


GEODETIC SURVEY OF CANADA
Noel J. Ogilvie, Director
DEFLECTIONS OF THE PLUMB LINE
Lines indicate direction and comparative intensity
Scale of Deflections in Meters
0 200 400 600 800
Statute Miles
100 0 100 200 300 400 500
To Dec. 31st. 1934
Geodetic station is at circle
Observed by U.S.Coast. and Geodetic Survey

sance nets, together with some of the easterly portion of the district of Kenora. The flying time on actual reconnaissance was 93½ hours.

Westerly from the Thunder Bay-Kenora boundary there are few outstanding hills, which made aeroplane reconnaissance a difficult operation. While the country is rough, gently grading to the prairies on the west, the tops of the hills are on much the same level, making the selection of intervisible hills from a plane quite uncertain. It had been anticipated that reconnaissance would be carried westerly to the prairies, but the above topographic conditions made it advisable to discontinue the aerial reconnaissance about 50 miles west of Sioux Lookout. From that point west ground parties, preferably with plane transportation, can doubtless lay down a suitable triangulation system.

Aerial Reconnaissance Statistics.—Combining the records of this and former aerial reconnaissance operations the statistics in the following table were computed and compiled. The flying times on which these figures were based do not include the time going to and returning from the area to be covered, but they include time moving from base to base and time flying to and from work from day to day.

AERIAL RECONNAISSANCE DATA

Operation	Area covered per flying hour	Axial distance along net per flying hour	Stations selected per flying hour
	sq. miles	miles	number
Northern Ontario, winter 1931	223	11	1·7
Northern Saskatchewan, April 1931	218	12	1·2
Northern Ontario, September 1931	354	11·5	1·4
Northern Ontario, winter 1935	179	9·9	1·54

In estimating the flying time for any proposed triangulation net a conservative figure of 200 square miles per flying hour is now employed. To this is added the time going to and returning from the area. This figure is worked out for topographic conditions which give stations at about 20-mile intervals, with hills reasonably prominent. In the September, 1931, operation, stations averaged about 30 miles apart and were quite prominent, allowing a large area to be covered with a minimum of flying time. In part of the area covered by the 1935 operation, lines were only from eight to ten miles long and hills were found only with difficulty, so the area covered per flying hour was correspondingly low.

GEODETIC ASTRONOMY AND ISOSTASY

Geodetic Astronomy.—The field work of the Division of Geodetic Astronomy consisted in the observing of longitude and latitude at the following triangulation stations: Riviere du Loup, Carleton, Richmond, and Chloridorme in the province of Quebec, and Bathurst, Belledune lighthouse, and Ashton in the province of New Brunswick. These observations were for the purpose of determining the deflection of the vertical and are a continuation of that work which has been in progress for some years. During the summer of 1935 it is expected two observing parties will make such observations in the provinces of Nova Scotia and New Brunswick.

International Longitude.—The observations made during the autumn of 1933 in connection with the world longitude campaign were reduced and carefully checked, and the results have been sent to the secretary of the International Union of Geodesy and Geophysics, in Paris. There were 517 longitudes determinations obtained from the observations made at the Geodetic Survey observatory.

Standards.—The work in the Standards Building of the Geodetic Survey of Canada was confined to the determination of the lengths of four invar wires, the property of the International Bureau of Lengths, in Paris. For the purpose of obtaining comparisons of lengths obtained at different laboratories the officers of the International Bureau sent four 24-metre invar wires to the several bureaus throughout the world which are affiliated with the International Bureau of Lengths. These wires were received by the Geodetic Survey of Canada in June and the work of determining their lengths from the standard nickel bar No. 10239 was completed on July 21. It is of interest to note that the lengths of these wires as determined by the Geodetic Survey of Canada agree closely with these lengths as determined at other laboratories on this continent. These tests serve to show that the lengths as used by the Geodetic Survey of Canada are in close agreement with lengths determined elsewhere. They also show that the methods employed in standardizing the base line tapes used in the field operations of the Geodetic Survey of Canada give results of a high degree of accuracy.

DIVISION OF LEVELLING ADJUSTMENTS

During the year 1934-35, publication No. 56 entitled " Recent Adjustments of the Precise Level Net of Canada " was issued. The purpose of this publication, as its name implies, was to review the adjustments of the level net which have been made since that of 1928, the results of which appeared in publication No. 28, and which are used in the series of publications issued by this survey giving the elevations of bench marks on precise level lines in the various provinces of the Dominion.

There are also, in this publication, some remarks on sea level on Atlantic and Pacific as it affects the level nets of Canada and the United States. Further work is being done in connection with the latter problem.

A short line of levels run in British Columbia in 1933 was added to the level net.

DIVISION OF TRIANGULATION ADJUSTMENTS

The work of this division during the last year has been confined largely to a continuation of the publication program outlined in previous reports.

The triangulation system at present consists of three detached units. Results for that portion of the Eastern unit extending from lake Huron easterly through Ontario and Quebec, covering the more settled areas of each province, and then southerly and easterly throughout New Brunswick, Prince Edward Island, and Nova Scotia, with an extension to the southwest coast of Newfoundland, have been issued in eight publications of this survey.

A continuation of this publication program has been made possible through the completion of the necessary observations in the Georgian Bay triangulation, which now permits the first tier of triangulation north of the previously published work to be adjusted for loop closures. It is proposed to incorporate these results in two issues, the first of which from Ottawa westerly and northerly up the valley of the Ottawa river and from its source to Cochrane and Senneterre, with an extension from Mattawa westerly through North Bay and Sudbury to the Georgian Bay area, has been prepared in manuscript form for publication.

The study of the geoid form, as derived from astronomic-geodetic comparison of values at coincident stations, has had to be discontinued because of lack of further data. The general study has been continued, however, and an isostatic geoid form determined for the area east of the 98th meridian of longitude.

An extensive study is proposed for the Gaspe, New Brunswick, and Nova Scotia areas to confirm the preliminary study. A distinctive feature is the pronounced rise of the geoid from the westerly and southerly limits towards the central portion of the gulf of St. Lawrence. Topography contributes but little to this rise and its true meaning is as yet obscure. The introduction of more astronomic-geodetic stations is needed to clarify the situation.

As in other years, requests from other government bureaus, engineering corporations, and private individuals have been received and the required information has been compiled and forwarded. These requests are constantly growing in number and reflect an increasing use of geodetic work as control in other survey operations.

DIVISION OF GEODETIC RESEARCH

After careful revision, the manuscript entitled "The Direct and Inverse Solutions of Long Geodetic Lines," dealing with geodetic lines of lengths as great as 500 miles, was printed and is now being distributed.

The solution of long lines has always been a problem of considerable interest to all countries carrying on geodetic work, and of special interest to those countries, such as Canada, where long lines will occur with considerable frequency.

PUBLICATIONS OF THE GEODETIC SURVEY OF CANADA

The following publications of the Geodetic Survey of Canada were printed: No. 41—"Altitudes in Quebec, South of St. Lawrence River"; No. 42—"Altitudes in Quebec, North of St. Lawrence River"; No. 54—"The Direct and Inverse Solutions of Long Geodetic Lines"; No. 56—"Recent Adjustments of the Precise Level Net of Canada," and the "Annual Report of the Director of the Geodetic Survey of Canada for the Fiscal Year Ending March 31, 1934." Magazine articles on the work of the Geodetic Survey of Canada were also prepared.

Special mailing lists compiled by means of notification cards, acknowledgment cards, and correspondence are used in the distribution of these publications.

PUBLICATIONS OF THE GEODETIC SURVEY OF CANADA

Publication No.

3—Determination of Lengths of Invar Base Line Tapes from Standard Nickel Bar No. 10239.

5—Field Instructions to Geodetic Engineers in Charge of Direction Measurement on Primary Triangulation.

8—Field Instructions for Precise Levelling.

11—Geodesy.

12—Statistics of the Geodetic Survey of London, Ont. (Distributed at London.)

14—Levelling, Co-ordination of Elevations of Bench Marks in Calgary, Alberta.

15—Bench Marks along Meridians, Base Lines and Township Outlines in Saskatchewan.

16—Levelling. Precise Levelling in Nova Scotia, New Brunswick and Prince Edward Island.

17—Levelling. Precise Levelling in Quebec South of St. Lawrence River.

18—Levelling. Precise Levelling in Quebec North of St. Lawrence River.

19—Levelling. Precise Levelling in Ontario South of Parry Sound.

20—Levelling. Precise Levelling in Ontario North of Parry Sound.

21—Levelling. Precise Levelling in Manitoba.

22—Levelling. Precise Levelling in Saskatchewan.

23—Levelling. Precise Levelling in Alberta.

24—Levelling. Precise Levelling in British Columbia.

25—The Conversion of Latitudes and Departures of a Traverse to Geodetic Differences of Latitude and Longitude.

26—The Simultaneous Adjustment of Precise Traverses and Triangulation Nets.

27—The Differential Adjustment of Observations.

28—Adjustment of Precise Level Net of Canada, 1928.

29—Triangulation in Southwestern Ontario.

30—Triangulation in New Brunswick and Nova Scotia.

31—Triangulation in Quebec and New Brunswick.

32—Triangulation in New Brunswick and Prince Edward Island.

PUBLICATIONS OF THE GEODETIC SURVEY OF CANADA—*Conc.*

33—Triangulation in Eastern Nova Scotia, Magdalen Islands.

34—Triangulation in Quebec.

35—Triangulation Closure in the Maritime Provinces.

36—Deflection of the Plumb Line in Canada.

Operations of the Geodetic Survey of Canada, April, 1912, to March, 1922. First General Assembly of the International Geodetic and Geophysical Union, Rome, 1922.

Operations of the Geodetic Survey of Canada, April, 1922, to March, 1924. Second General Assembly of the International Geodetic and Geophysical Union, Madrid, 1924.

Operations of the Geodetic Survey of Canada, April, 1924, to December, 1926. Third General Assembly of the International Geodetic and Geophysical Union, Prague, 1927.

37—Geodetic Operations in Canada—January 1, 1927, to December 31, 1929. Reports of the Section of Geodesy—The International Geodetic and Geophysical Union, Fourth General Conference, Stockholm, 1930.

38—Precise Levelling on Vancouver Island.

39—Altitudes in Nova Scotia and Prince Edward Island.

40—Altitudes in New Brunswick.

41—Altitudes in Quebec, South of St. Lawrence River.

42—Altitudes in Quebec, North of St. Lawrence River.

47—Altitudes in Saskatchewan South of Latitude 50° 31′.

48—Altitudes in Saskatchewan North of Latitude 51° 30′.

53—Geodetic Operations in Canada—January 1, 1930, to December 31, 1932. Reports of the International Association of Geodesy. The International Geodetic and Geophysical Union, Fifth General Conference, Lisbon, 1933.

54—The Direct and Inverse Solution of Long Geodetic Lines.

55—Triangulation in Southeastern Ontario.

56—Recent Adjustments of the Level Net of Canada.

Annual Report of the Superintendent of the Geodetic Survey of Canada for the fiscal year ending March 31, 1918. The same for the year 1922.

Annual Reports of the Director of the Geodetic Survey of Canada for the fiscal years 1923, 1924, 1925, 1926, 1927, 1928, 1929, 1930, 1931, 1932, 1933, 1934, 1935.

Where name and number (or year) are omitted, the publication is not available for distribution.

Copies of the above publications may be obtained by applying to the Director of the Geodetic Survey of Canada, Department of the Interior, Ottawa.

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